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THE RELATIONSHIP OF CERTAIN "FREE-LIVING" AND SAPROPHYTIC MICROORGANISMS TO DISEASE[1]

IT seems profitable on this occasion to endeavor to take in review the progress of our knowledge of the broader outlines of biological development in respect to some of those microorganisms which at least during one stage of their existence may be referred to as free-living, saprophytic or symbiotic, and of their potentiality in a different environment to assume a parasitic existence and produce disease. A considerable growth of our knowledge of several of the microorganisms to be discussed in this connection has very recently occurred. Obviously a consideration of this nature should demand much insight into the fundamental problems which relate to the microorganisms in question, and a careful investigation not only of their morphological details but, as well, of those of a physiological and pathological nature, and of the effects of changed environment and of evolution on the microorganism. It is only through such careful observations of form, function and reaction, and by series of experimental inoculative procedures in artificial culture media, or in different animals or plants in which the microorganism is given a new environment, that we can be brought to appreciate such evolutionary changes as occur, and the relationships which exist between certain allied species morphologically indistinguishable.

Evidently the accurate determination and recognition of the species under investigation in the different environments is a primary requisite of such an investigation. This, however, particularly in the case of some of the protozoan or protistan microorganisms to be discussed, is beset with many difficulties.

There has been some difference of opinion as to whether or not some of those spirochætes which have been supposed to be purely saprophytic and to lead a free existence might, under other conditions, acquire pathogenic properties. It has been suggested that by mutation and adaptation they may in some instances be able to become transformed from harmless saprophytes into highly pathogenic parasites. Neumann[2] believes that non-parasitic saprophytic spirochætes

[1] Address of the retiring vice-president, Section N (Medical Sciences). Read at the annual meeting of the American Association for the Advancement of Science, December, 1924.

[2] Neumann, *Central. f. Bakt.*, 1923, XC, Heft 2, p. 100.

can rather quickly change in character and acquire pathogenic properties. He calls attention to the fact that two of his experimental rabbits acquired genital spirochætosis through contamination by manure which contained the microorganisms. Other observers have objected to these conclusions and believe that in Neumann's experiments in rabbits, the possibility of infection of the wounds with spirochætes from the intestine was not excluded. Moreover, Warthin, Buffington and Wanstrom[3] have recently emphasized the fact that infection with a form of spontaneous venereal spirochætosis in rabbits may occur and spread by both contact with other infected rabbits or by coition. Worms[4] has also claimed to have induced typical genital spirochætosis in rabbits by inoculating them with *Spirochæta dentium* of the normal human mouth, but it has also been objected that no proof is given that the spirochætes which persisted in the lesions were actually pathogenic to the animals, and that they might merely have survived as saprophytes.

In this connection some studies have recently been carried out with the presumably saprophytic species of spirochætes found in the human intestine. Werner, in 1909, described two types of spirochætes found in his own stool after typhoid fever. One of these he named *Spirochæta eurygyrata,* which was loosely coiled, very active and flexible, with rarely more than two spirilla, mostly as "S" forms. The other type, called *Spirochæta stenogyrata,* was tightly coiled, not so active and less flexible. It is well recognized that in apparently healthy persons spirochætes may be sometimes found in small numbers in the feces, and that in other individuals suffering with some form of colitis enormous numbers of spirochætes are sometimes encountered. In the latter instance, *Spirochæta eurygyrata* has often been regarded as the excitant factor. Le Dantec, Luger and others have believed that the intestinal spirochætes may give rise to a form of dysentery. However, the investigations of Muhlens, Macfic, Pons and others suggest that at times at least this spirochæte may exist in the intestine as a harmless saprophyte. Delamare[5] has raised the question of the intensity of infection with spirochætes in the human intestine which indicates the border-line between health and disease. From his investigations he regards from six to ten spirochætes per microscopic field as the standard to adopt. He believes that the spirochætes multiply rapidly when the intestine is in a condition favorable to their growth, such for example as exists in cholera or in amoebic dysentery. Without attributing any pathogenic properties to the spirochætes in this locality, he believes their presence in large numbers is nevertheless an indication that the intestine and especially the colon is in an abnormal condition. Parr[6] has found that spirochætes can be demonstrated in about one third of the healthy persons about Chicago, though the intensity of the infection is slight. The spirochætes were localized in the cecum and ascending colon and in many cases did not appear in the feces.

Attempts to infect successfully animals with *Spirochæta eurygyrata* and similar intestinal spirochætes have not been conclusive.

Blanchard[7] is reported to have introduced the exudate from the false membrane of a case of Vincent's angina into the digestive tube of a dog and produced a dysenteriform state in the animal in which both spirochætes and fusiform bacilli were recovered from the stools. However, Tanon, who studied the effects of subcutaneous, intravenous and intraperitoneal injections of spirochætal intestinal material into guinea pigs, rabbits and monkeys, only obtained negative results.

Teissier and Richet[8] also fed rabbits and guinea pigs fecal suspensions rich in spirochætes and obtained only negative results. When the material was injected subcutaneously, abscesses were formed, but they contained no spirochætes. When intraperitoneal injections were made into guinea pigs, the peritoneal cavity was found to be subsequently rich in spirochætes, but when some of the fluid was injected into a second series of guinea pigs, no spirochætes were obtained.

Hassenforder[9] reported positive results only when the fecal suspensions containing spirochætes were associated with virulent amoebae and injected intrarectally into cats.

Hogue[10] fed three cats 6 cc of a culture of *Spirochæta eurygyrata,* but no spirochætes were subsequently found in the stools.

Parr[11] injected feces containing spirochætes intraperitoneally into six guinea pigs, and in no case was an abdominal exudate found containing spirochætes. Intratesticular injections in rabbits were also negative. The exact nature of the material injected and the approximate number of spirochætes in it is not stated. Apparently the fusiform bacillus was not present.

[3] Warthin, Buffington and Wanstrom, *Jour. Infect. Dis.,* 1923, XXXII, 315.

[4] Worms, *Klin. Woch.,* 1923, II, 836.

[5] Delamare, *Bull. et Mem. Soc. Med. Hopit. de Paris,* 1924, XLVIII, 725.

[6] Parr, *Jour. Infect. Dis.,* 1923, XXXIII, 369.

[7] Blanchard, cited by Hassenforder, Thesis, Lyons, 1914.

[8] Teissier and Richet, *Bull. et Mem. Soc. Med. Hopit. de Paris,* 1911, XXXI, 775.

[9] Hassenforder, Thesis, Lyons, 1914.

[10] Hogue, *Jour. Exper. Med.,* 1922, XXXVI, 617.

[11] Parr, *Jour. Infect. Dis.,* 1923, XXXIII, 379.

Broughton-Alcock,[12] however, attaches a definite etiological significance to *Spirochæta eurygyrata* in certain chronic and intermittent cases of dysentery, and he found that the organism occurs in great numbers in the mucus passed in the acute and subacute stage of such cases when no other microorganism is present to account for the pathological condition. His experience has led him to believe that *Spirochæta eurygyrata* can produce in human beings a catarrhal condition of the intestine with the passage of mucus containing shed degenerated epithelial cells, occasionally red blood cells, and, rarely, typical dysenteric symptoms. He adds that there is always the argument that a primary agent has produced a vulnerable surface over which the organism acts symbiotically. The idea of the spirochæte having acquired pathogenic properties or an increased virulence in this condition is not suggested, but he believes that the spirochæte of somewhat similar but not identical form found in the normal feces is *Spirochæta stenogyrata,* which is non-pathogenic, *Spirochæta eurygyrata* being found only in the mucus and not in the feces. Attempts to infect mice with *Spirochæta eurygyrata* were unsuccessful. Davis and Pilot[13] believe that some cases of gangrenous appendicitis appear to arise from the fusiform bacilli and spirochætes of the intestine which have acquired a new virulence.

The relationship to bronchial spirochætosis of *Spirochæta bronchialis* (morphologically similar to *Spirochæta vincenti, Spirochæta schaudinni,* and *Spirochæta refringens*) raises the question of whether there is an acquired pathogenesis for this species in this condition. The recent investigations of Pons[14] further substantiate the view that the spirochætes in the sputum in bronchial spirochætosis are really similar to those described as occurring in the human mouth by many observers and that possibly they may have found in this pathological condition in the bronchi a suitable medium for further development. Perhaps such a favorable medium also occurs in tuberculosis and in certain other pathological conditions of the lung. Trocello has expressed the view that the oral spirochætes can extend directly to the bronchi. Pons studied nine cases of bronchial spirochætosis and came to the conclusion that it was impossible to confirm deMello's[15] observations that the bronchial spirochætes are distinct from those of the mouth. He was not able to differentiate *Spirochæta buccalis* from *Spirochæta bronchialis.* He was also not able to confirm such statements as those which affirm that the oral forms are less motile and retain their motility longer than the bronchial forms, and do not produce the coccoid bodies to the same extent. He however did observe a rapid loss of motility in the bronchial forms. Attempts to reproduce the disease bronchial spirochætosis by intratracheal inoculation of normal rabbits failed. He however does not believe that the spirochætes encountered in pathological conditions of the lung are purely saprophytic but rather that they afford evidence of an abnormal condition due to varying causes, and that they are able to give to these conditions characteristics such as chronicity and ulceration which one is accustomed to associate with the occurrence of spirochætes in a lesion.

Obviously, still further investigation is desirable upon the question of the pathogenicity under some circumstances and under the influence of some possibly symbiotic microorganism or bacteriophage, of *Spirochæta bronchialis* and the morphologically similar forms.

In the mouth and from the genital organs of some individuals spirochætes have been observed living apparently as harmless saprophytes which are morphologically indistinguishable from some of the well-recognized pathogenic species. These organisms have been found in association with fusiform gram-negative bacilli not only in these situations but particularly in the lesions about carious teeth and in gangrenous putrid infections about the mouth. Broughton-Alcock[16] has found spirochætes with other bacteria in a catarrhal exudate from the antrum, and Tunnicliff has observed them in a frontal sinus. Davis and Pilot[13] have recently emphasized the importance of the occurrence of spirochætes and fusiform bacilli not only in Vincent's angina but in ulceromembranous stomatitis, noma, putrid otitis media, putrid bronchitis and gangrenous pneumonia. They believe that such conditions are usually caused by these organisms which presumably come from the mouth or tonsils or both. They also conclude that the several gangrenous processes that occur at times about the male and female genitals presumably result from invasion by these organisms that occur normally there. They inoculated material containing fusiform bacilli and spirochætes and pyogenic cocci from teeth, tonsils, smegma and putrid sputum, both intrapleurally and subcutaneously into rabbits, and obtained putrid and gangrenous lesions containing these organisms. The cocci, especially streptococci, were found to be the most aggressive organisms and sometimes alone invaded the adjacent cavities and the

[12] Broughton-Alcock, Proc. Roy. Soc. Med., 1923, XVI, Pt. 3, p. 46.

[13] Davis and Pilot, Collected Studies from the Dept. of Pathology and Bacteriology, Univ. of Illinois, Chicago, 1922–1923, p. 27.

[14] Pons, *Bull. Soc. Path. Exot.,* 1924, XVII, 170.

[15] deMello, *Bol. Geral. Med. e Farmacia,* Bastora, 1924, Feb. 9th series, p. 46.

[16] Broughton-Alcock, Trans. Roy. Soc. Trop. Med. & Hyg., 1923, XVII, 337.

blood stream. The fusiform and spirochætal organisms tended to remain more locally, causing necrosis and gangrene in the already invaded tissues. Predisposing factors are considered usually as of first importance in determining the development of the microorganisms, and they believe that at times they may, like bacteria, develop a degree of virulence sufficient to enable them to gain a foothold in the normal tissue.

The free-living spirochætes of water have generally been considered as saprophytic organisms. They have been found in fresh and in marine water, often more particularly when the water is stagnant and when through the decomposition of protein in the presence of ammonia, nitrites and nitrates, hydrogen sulphide gas is freely generated. They are also often found on the surface of filters, about the apertures of water taps, and on the undersurface of metal closure caps of certain bottled drinking waters in northern Brazil. A number of these spirochætes correspond morphologically with the parasitic species, such as *Treponema pallidum* of syphilis, *Leptospira icterochæmorrhagiae* of Weil's disease, *Spirillum obermeieri* of relapsing fever, and *Spirochæta hebdomadis* of seven-day fever. We have referred to the fact that in the mouth and in the genitals of some healthy human beings there occur spirochætes which are morphologically indistinguishable from certain of the well-known pathogenic species such, for example, as some of those just enumerated, but several of these spirochætes from the mouth and genitals are also morphologically indistinguishable from some of the spirochætes found recently in water. Evidently, therefore, morphological resemblances alone are entirely insufficient for us longer to attempt to differentiate spirochætes generally into different species, nor are they obviously sufficient for us to establish the identity of a number of these water spirochætes with some of the species known to cause disease. Animal inoculations in some instances, however, have furnished additional evidence in this respect.

Spirochæta schaudinni, morphologically identical with *Spirochæta vincenti* and *Spirochæta refringens,* has been encountered by many observers in open ulcers of the skin.

Very often the spirochætes in such lesions have been found associated with fusiform bacillary forms. These organisms in certain localities and lesions are practically always associated. By some observers they are regarded as distinct organisms, perhaps living symbiotically, while by others the fusiform bacilli and spirochætes are believed to be merely different forms in the life-cycle of one organism.

Ruth Tunnicliff[17] holds the latter view. She admits, however, that there are several different strains of fusiform bacilli.

In portions of northern and central Brazil, chronic ulcerative processes of the skin are exceedingly common, and in one form of tropical ulcer, *Spirochæta vincenti* and fusiform bacilli are invariably present and apparently constitute the most important etiological factor in this particular form of ulcer. The spirochætes and fusiform bacilli are found in abundance not only on the surface of the lesions, but usually extending for at least several millimeters into the tissue surrounding the ulcer. Numerous cocci and other bacilli are also usually encountered in the exudate upon the surface of the ulcers. Small pieces of tissue were removed from a number of these ulcers, and after they had been thoroughly rinsed in sterile normal saline solution were ground up in a mortar, resuspended in other saline solution, and the suspension injected subcutaneously into monkeys and also intratesticularly, after injury, into rabbits. Suppurative and ulcerative lesions were produced in these animals thereby, in which both spirochætes and fusiform bacilli as well as cocci were found present.[18]

It seems probable that *Spirochæta vincenti* can not usually establish itself in healthy skin or even in many aseptic wounds, but if the integument is bruised, burned or otherwise injured and the circulation interfered with and the vitality of the tissues otherwise impaired, it may often assume pathogenic properties and a phagedenic ulceration result. The recent observations of Van Nitsen[19] are also in accord with this view.

In view of the fact that there are in some waters spirochætes which are morphologically indistinct, or very similar to *Spirochæta vincenti,* experiments were undertaken to see if these spirochætes were also pathogenic for animals. In Manaos various samples of stagnant water and scrapings from the surface of filters and apertures of water taps and under-surface of caps of mineral water bottles were suspended in saline solution, were centrifuged and the sediments which contained spirochætes resuspended in saline solution and injected subcutaneously and intraperitoneally into mice and guinea pigs and subcutaneously into monkeys.[18]

Only negative results were obtained. The animals remained healthy, and we were entirely unable to produce any lesions such as had been done with the material obtained from the tropical ulcers. Our experiments with the spirochætes from tropical waters,

[17] Tunnicliff, *Jour. Infect. Dis.,* 1923, XXXIII, 147.

[18] These experiments were undertaken in conjunction with Dr. George C. Shattuck and Mr. Ralph Wheeler, and will be reported upon in detail elsewhere.

[19] Van Nitsen, *Annales Soc. Belge de Med. Trop.,* 1924, III, 317.

however, are far from being complete and are not conclusive, since the spirochætes employed in our inoculations were never obtained and injected in large numbers. On my return to this country I found that Noguchi[20] had studied some of the spirochætes which he had isolated from more or less stagnant ponds, swamps and ditches in the northern United States, and had previously reported on this study. He obtained growth of the water leptospiras in impure culture on his regular leptospira media, though with considerable difficulty. Inoculations of the leptospira water samples into guinea pigs, white rats and mice were repeatedly made, but no infection could be induced in the animals. His injections of cultures likewise proved to be harmless. The kidneys and liver of the inoculated rats were removed after three weeks and suspensions of these organs injected into guinea pigs with the hope that passage through rats might have enhanced the virulence of the organisms, but no positive results were obtained. Noguchi has concluded that the water leptospiras which he studied appeared to be non-pathogenic for guinea pigs as well as rats.

On the other hand, Uhlenhuth and Zuelzer[21] have isolated by culture from aqueduct water a spirochæte which subsequently acquired distinctly pathogenic properties for animals. This spirochæte in doses of 2 to 4 cc of the culture, when injected intraperitoneally, produced in guinea pigs a disease which after four to eight days caused death. The entire appearance in the animals so infected corresponded with that of Weil's disease. This water spirochæte was also pathogenic for mice. Zuelzer regards this spirochæte as identical with the one which produces human Weil's disease. The cultures were made in sterile tap water to which was added 15 to 20 per cent. of rabbit serum. Before being inoculated the tubes were warmed for an hour at from 55° C. to 60° C., in order to inactivate the serum. By frequent inoculation from the surface of such culture the spirochætal growth was increased. The culture of the spirochæte obtained was not pure, but was mixed with a coccus, but the coccus when injected alone into the animal produced no pathogenic changes. It is reported that with two of the water strains isolated, a potent immune serum against *Spirochæta icterohaemorrhagiae* was made.

From these experiments and others of a similar nature, Zuelzer and Oba[22] conclude that non-parasitic, saprophytic spirochætes may become under certain conditions pathogenic, but that such changes come about very slowly. Thus the strain of *Leptospira icterohaemorrhagiae,* which was isolated from water, it is stated only became pathogenic for guinea pigs after it had been cultivated in serum media for one and one fourth years. Elaborate serological and biological experiments were carried out which demonstrated the identity of this strain with the natural pathogenic strain of *Leptospira icterohaemorrhagiae* of Weil's disease.[23] This is the most striking example reported of a free-living, saprophytic spirochæte which has gradually acquired definite pathogenic properties.

The subjects of symbiosis and mutualism and their relationship to parasitism because of their broad biological interest should appeal not only to the physiologist and pathologist, but to the zoologist as well. These phenomena which have so frequently been observed among both animals and plants may affect profoundly their structure and behavior, or even their existence. The term "symbiosis," which has sometimes been misapplied in medical literature, signifies a condition of conjoint life existing between different organisms of varied or even the same species, both organisms being benefited by the partnership. Obviously a condition of perfect symbiosis with different species is very rarely if ever realized either in plants or animals, since such a condition would require that each of the organisms should render to the other an exact equivalent of what it received, and that the organisms in question should be entirely adapted to a life in common. This ideal balance, even if attained, becomes frequently disturbed, and in some groups of animals sooner or later one organism becomes more dependent upon the other and the symbiotic relationship passes into one of parasitism, in which the degree of adaptation may vary greatly. Thus, the new condition may approach that of symbiosis and a mild parasitism result, or it may pass to the other extreme, one organism assuming highly pathogenic properties for the other and perhaps causing its destruction. Again, certain forms of parasites do not nourish themselves on any part of the host. They belong to the group of commensals or more correctly, according to Fantham and Stephens, of "space parasites" which simply dwell within their host and do not even take a portion of the superfluity of its food. However, the presence of such "space parasites" may be regarded as constituting the first stage of commensalism which, in

[20] Noguchi, *New York State Jour. Med.,* 1922, XXII, 426.

[21] Uhlenhuth and Zuelzer, *Central. f. Bakt. u. Parasit.,* 1922–23, Orig., LXXXIX, 171.

[22] Zuelzer and Oba, *Central. f. Bakt. Abt. I,* Orig., 1923–24, XCI, 95.

[23] Buchanan has since isolated a similar microorganism from mud and slime. See *British Med. Jour.,* Nov. 29, 1924, p. 990.

turn, may again be regarded as a sort of transition stage to true parasitism.

On the other hand, in some instances it is conceivable that the symbiosis originates through a preliminary stage of parasitism on the part of one of the organisms, the struggle for supremacy ending in mutual adaptation. In either instance it is evident that there is no definite boundary between symbiosis and parasitism. As Nuttall[24] has pointed out, the factors governing immunity from symbionts or parasites are essentially the same. The condition of life defined as symbiosis may then be regarded as balancing between two extremities, complete immunity on the one hand and deadly infective disease on the other.

Among insects there are found innumerable examples of such progressive adaptations toward an association with microorganisms of different type. Nuttall has classified symbiosis in insects into four groups: (1) the utilization by insects of microorganisms cultivated by them outside their bodies; (2) symbiotic organisms developing in the lumen of the intestine and its adnexa; (3) intestinal symbionts situated in the epithelial cells of the digestive apparatus; and (4) intracellular symbionts of deep tissues. The symbionts may be bacteria, yeasts, saccharomycetes, protozoa or rickettsia. Various hypotheses have been advanced to explain the possible function of the symbionts, but our knowledge of this subject is still very meager. Even the classification of these microorganisms is sometimes difficult. Thus Buchner[25] has found symbionts in *Cimex lectularius* which live in large cells called mycetocytes or within a new symbiotic organ, the mycetome. These microorganisms he regards as bacteria. On the other hand, Arkwright, Atkin and Bacot[26] have described a similar microorganism in *Cimex* under the term *Rickettsia lectularia*. Also Jungmann[27] and Arkwright and Bacot[28] have described in the sheep louse, as stages of *Rickettsiae*, certain forms which are regarded by Hertig and Wolbach[29] as yeasts or "yeast-like" organisms.

The recent observations of Hertig and Wolbach (*loc. cit.*) only serve to emphasize how much confusion there still exists regarding the forms of life so widely distributed throughout the arthropods and which have recently been referred to under this term of *"Rickettsiae."* They also demonstrate the great difficulties in the recognition of *Rickettsia*, some observers regarding the forms described under this term as yeasts, bacteria, symbionts or even as degenerated cell products or flagella of protozoa. While the cultivation of some of the pathogenic species of *Rickettsia* has been described, until more satisfactory methods of culture are discovered and direct inoculations made into man or susceptible animals with these pure cultures, even the etiological relationship of at least most of these forms to disease must still remain somewhat obscure.

As the writer pointed out some years ago[30] certain of the *Rickettsia* of *Pediculi* which are harmless to man, as was demonstrated by experiments in which such *Pediculi* were fed on healthy human beings, can not be distinguished morphologically or by any other known means from the *Rickettsia* believed by some observers to be the cause of disease (trench fever). However, there is no evidence of any of these symbionts being pathogenic for the arthropod, and among the *Rickettsiae* only *Rickettsia prowazeki* exhibits moderate pathogenicity for its insect host, while the *Rickettsia* described as the cause of Rocky Mountain spotted fever would appear to be a harmless parasite rather than a symbiont to its insect host, the tick (*Dermacentor venustus*). Wolbach believes that this *Rickettsia* is probably parasitic in process of adaptation to the tick. The view recently expressed by Weigl[31] that *Rickettsia prowazeki* is merely the form assumed by *Bacillus proteus X* in the louse seems hardly tenable.

As no one has succeeded yet in cultivating on artificial media the symbionts of blood-sucking insects, their true nature is also still undetermined. Florence[32] has recently studied the symbiont in the hog louse, *Haematopinus suis*, and has been able to obtain some evidence in favor of the view that it is connected with the physiology of digestion in the insect in that the location of the mycetocytes containing the symbiont is in the mid-intestine where digestion takes place; that the mechanical control of the increase of the symbiont is through the rupture of the mycetocytes; that there is careful provision for transmission of the symbiont to the next generation and an inability to raise a second generation of it when the lice are removed from their natural host and fed on man.

[24] Nuttall, Rep. Brit. Assoc. for Adv. Sc., 1923, p. 197.

[25] Buchner, "Tier. u. Pflange in intracellular Symbiose," Berlin, 1921, and *Arch. f. Protist.*, 1923, XLVI, 225.

[26] Arkwright, Atkin and Bacot, *Parasitology*, 1921, XIII, 27.

[27] Jungmann, *Deut. med. Woch.*, 1918, XLIV, 1346.

[28] Arkwright and Bacot, Trans. Roy. Soc. Trop. Med. & Hyg., 1921–22, XV, 146.

[29] Hertig and Wolbach, *Jour. Med. Research*, 1924, XLIV, 329.

[30] Strong, Contributions to Med. and Biol. Research dedicated to Sir Wm. Osler, 1919, p. 1205.

[31] Weigl, *Zeit. f. Hyg. u. Infekt.*, 1923, XCIX, 3, p. 308; *Klin. Wochen.*, 1924, Aug. 26, III, No. 35, p. 1590.

[32] Florence, *Amer. Jour. Trop. Med.*, 1924, IV, 397.

Wheeler[33] has recently emphasized the importance of the study of the phenomenon of symbiosis and parasitism in many species of ants and termites, and of the importance in the lives of certain termites of the existence of the numerous intestinal infusoria or flagellates. These occur only in the soldiers and workers of the termites and have been variously interpreted as parasites, commensals and symbionts. The recent investigations of Imms[34] and of Cleveland[35] are confirmatory of the idea that these protozoa of termites are true symbionts which break down the particles of wood ingested for food and render them more easily assimilable by the termites. The termites themselves, as Cleveland has shown, die in ten to twenty days if fed on wood after the protozoa have been removed from them because they can not digest their food. On the other hand, the termites do not die but live indefinitely when fed digested wood or when reinfected with protozoa and fed wood. Hence he believes that it is highly probable that the termites are dependent on the protozoa to digest thir food for them.

Buscalioni and Comes state that *Trichonympha agilis,* harbored by *Reticulitermes lucifugus,* when treated with iodine dissolved in iodide of potassium, gives a characteristic glycogen reaction in a region near the nucleus, and that this reacting region is sharply defined from the rest of the body. Cutler[36] could not locate a definite glycogen reacting area in *Pseudotrichonympha pristina,* harbored by *Archotermopsis wroughtoni,* but, on the contrary, found that the glycogen reaction was diffused through the entire organism. According to Certes glycogen is present in the protoplasm of the infusoria and the latter perform a special rôle in the digestion process of certain ruminants.

In the study of parasites of termites in Brazil, numerous gregarines, flagellates and spirochætes were found in great abundance in the intestine. While no information was obtained as to whether these microorganisms lived symbiotically within their host, none of them seemed to affect unfavorably the life of the termites and apparently they led therein a saprophytic existence. The spirochætes observed were particularly of two types: In the first type, the organism measured from 65 to 75 μ in length and from 1 to 1½ μ in thickness. The ends were rounded. They showed seven to eight spiral turns. The second type measured from about 40 to 50 μ in length, and about 1 μ in thickness, the extremities being tapering and pointed. These spirochætes seemed more motile than those of the first type. They also had from seven to eight spiral turns. These two types observed in termites in Brazil probably correspond to *Treponema termitis* (Leidy) and *Treponema minei* (Prowazek) which have recently been described particularly by Hollande.[37]

In continuance of our experiments with saprophytic spirochætes, inoculations of suspensions in normal saline solution of portions of the intestinal contents of termites containing spirochætes were also made into white mice and guinea pigs.[38] The inoculations were made both subcutaneously and intraperitoneally.

In the experiments in which the inoculations were made intraperitoneally into guinea pigs, drops of fluid were often withdrawn from the abdominal cavity by means of a capillary glass pipette about two hours after the inoculation, and examined under the microscope and with the dark field illumination, but no living spirochætes were found and no evidence of the pathogenicity of these spirochætes was obtained from either the intraperitoneal or subcutaneous inoculations into mice and guinea pigs.

Turning to more highly organized forms of protozoa, the majority of the recent experiments reported, in which subcutaneous or intraperitoneal inoculation of laboratory animals such as mice and guinea pigs have been made with the flagellates which are found in insects, and which live an apparently saprophytic existence in them, have generally resulted negatively. Laveran and Franchini[39] reported the successful infection of mice by causing them to ingest material containing *Herpetomonas ctenocephali* or by inoculating them subcutaneously with this flagellate, and Fantham and Porter[40] reported that young mice may be inoculated subcutaneously or fed with *Herpetomonas jaculum* from the gut of the hemipteron *Nepa cinerea,* the so-called water scorpion, with fatal results. On the other hand, Hoare[41] was unable to infect fifteen mice by intraperitoneal inoculation of *Herpetomonas jaculum.* Chatton[42] also inoculated a suspension of thirty dog fleas containing *Herpetomonas ctenocephali* intraperitoneally into two mice, but the results were negative. Noller[43] likewise only obtained negative results in the inoculation of mice with pure

[33] Wheeler, "Social Life among Insects," New York, 1923.

[34] Imms, Proc. Roy. Soc., London, 1919, 209B, p. 75.

[35] Cleveland, *Biol. Bull.,* 1924, XLVI, 179.

[36] Cutler, *Quarterly Jour. Micro. Sci.,* 1921, LXV, 247.

[37] Hollande, *Arc. Zool. Exp. et. Gen.,* 1922, LXI, 23.

[38] These experiments were undertaken in conjunction with Dr. Joseph Bequaert and Mr. Ralph Wheeler.

[39] Laveran and Franchini, *Bull. Soc. Path. Exot.,* 1914, VII, 605.

[40] Fantham and Porter, Proc. Camb. Philosophical Soc., 1915, XVIII, 39.

[41] Hoare, *Parasitology,* 1921, XIII, 67.

[42] Chatton, *Bull. Soc. Path. Exot.,* 1919, XII, 313.

[43] Noller, *Arch. f. Schiffs. u. Tropen.,* 1920, XXIV, 168.

cultures of *Herpetomonas ctenocephali*. Recently Glaser[44] and Becker[45] were also unable to infect animals by subcutaneous or intraperitoneal inoculation of other species of flagellates; namely, *Herpetomonas muscae-domesticae* and *Crithidia gerridis*. Shortt[46] in extensive experiments has, in addition, failed to infect vertebrates with *Herpetomonas ctenocephali* and *Herpetomonas luciliae*. During the past year, however, two successful reports of the inoculation of mice with other flagellates of insects have been made. The first of these results was obtained by Shortt and his coworker Swaminath,[47] whose negative results with other flagellates of insects have just been referred to, and these positive results are therefore more striking. Bedbugs (*Cimex hemiptera*) were fed on cases of kala azar which showed parasites in the peripheral blood. They were dissected nine days later and the contents of the guts were suspended in saline solution and injected intraperitoneally into mice. The minimum period of nine days was chosen, as it was presumed that at the ninth day all the forms present would be in the flagellate condition. Of five mice which were inoculated with the suspension of twelve to twenty of the insects' intestines, one gave a positive result on the 123rd day, a culture of the flagellate being obtained from the spleen. Shortt concludes that it is thus demonstrated that nine days after feeding bedbugs on a kala azar case, the intestine of these insects may contain flagellate of leishmania which are infective to mice.

Gaminara[48] found the Uruguayan *Triatoma* to be naturally infected with intestinal flagellates corresponding morphologically to the developmental forms of *Schizotrypanum cruzi* in the insect. Inoculations of experimental animals with these flagellates resulted in their infection. The infected animals showed in their cardiac and skeletal muscles the typical leishmania-like forms of the parasite.

During the previous year the writer[49] has shown that a flagellate which passes one stage of its life-cycle in *Euphorbiae* and which is not pathogenic for laboratory animals when inoculated from such an environment may, after its passage from the plant through its insect and vertebrate hosts, acquire pathogenic properties for monkeys. This is apparently another striking example of a microorganism which in its adaptation to changed environment gradually acquires pathogenic properties. The effect of environment upon species in all forms of life both in suppressing or bringing inherent potentialities to expression seems unquestionable, and either physiological or morphological changes may be developed in a parasite as a result of exposure to altered environment.

Even with lower forms of life, the bacteria, we are cognizant of examples of somewhat similar phenomenon. Thus Courmont and Rochaix[50] have found, as have other investigators previously, that by frequent subculture of the four types of bacillary dysentery bacilli on the same sugar media, they come in time to acquire the power of splitting that particular carbohydrate. One generation of organisms can be trained to ferment a sugar to which it is unaccustomed. While this property lasted usually only for that generation and could not be transmitted to the next, there were certain exceptions to the rule.

D'Herelle[51] reported that under the influence of his bacteriophage it was possible to produce secondary races from the original Shiga strain of the dysentery bacillus which differed mainly in their power of fermenting certain sugars.

Busson and Ogata[52] have very recently reported experiments, using eleven strains, of Shiga, Strong, Flexner and Schmitz types of dysentery bacilli and three bacteriophages. By injecting rabbits with a mixture of original strains which had been acted upon in a typical maner by the bacteriophage, agglutinating sera were prepared. The sera thus prepared were tested against the original and secondary strains. By these means it was shown that the secondary races were no longer agglutinated by the original serum. The authors believe that the secondary races are divisible into two types: those which permanently retain the newly acquired properties and those which do not.

Fejgin[53] also found that the dysentery bacillus under the influence of its lytic bacteriophage substance produced a new race differing both in serological and biochemical properties from the original strain of Shiga's bacillus.

Reference has been made to the fact that animals even as high in the scale of life as insects find it difficult or impossible to digest crude cellulose. In this connection Imms[54] has pointed out that the symbiosis between the intestinal protozoa and the termites is paralleled by the occurrence of numerous genera of

[44] Glaser, *Jour. Parasitol.*, 1922, VII, 99.

[45] Becker, *Amer. Jour. Hyg.*, 1923, III, 462.

[46] Shortt, *Indian Jour. Med. Res.*, 1923, X, 908.

[47] Shortt and Swaminath, *Indian Jour. Med. Res.*, 1924, XI. 965.

[48] Gaminara, Annales de la Fac. de Med. Montevideo, 1923, VIII, 311.

[49] Strong, *Amer. Jour. Trop. Med.*, 1924, IV, 345.

[50] Courmont and Rochaix, *Jour. Physiol. et Path. Generale*, 1924, XXII, 377.

[51] D'Herelle, "Le Bactériophage," Monographies de l'Institut Pasteur, 1921.

[52] Busson and Ogata, *Wien. klin. Woch.*, 1924, XXXVII, 665.

[53] Fejgin, *Compt. Rend. Soc. Biol.*, 1923, LXXXIX, 1381.

[54] Imms, Philosophical Tr. Roy. Soc. London, 1919, 209B, pp. 75–180.

infusoria in the stomachs of ruminants, notably of the ox, sheep, goat, camel and reindeer. It is believed that by means of their action upon the vegetable matter consumed by the ruminants these infusoria help to render it capable of being digested by the latter. These infusoria are absent from the stomachs of the young ruminants prior to being weaned from their parents. According to Certes, glycogen is present in the protoplasm of the infusoria and the latter perform a special rôle in the digestive process of the ruminants. Cruby and Delafond maintained that the protoplasm of the infusoria is itself digested and thereby contributes towards the nutrition of the host ruminant. Similarly, the infusoria inhabiting the large intestine of the Equidae, Imms states, are possibly symbiotic in their relations with their host. Whether a true symbiosis exists in a number of these instances seems questionable. It is true that the ciliated infusorium, *Balantidium coli*, lives commonly in the normal intestine of pigs apparently as a harmless commensal. There is no evidence in favor of or contrary to the fact that it lives in symbiosis with its host. Glaessner has reported the isolation of a diastase and a hemolysin from this infusorium, but no proteolytic ferment has been yet obtained. It is also not known that it plays any special rôle in the digestive process of the pig. However, when this infusorium enters and lives for a time in the large intestine of man or in orangutans, under certain conditions which we can not fully explain, it gradually assumes pathogenic properties and invades the tissue, giving rise to an ulcerative form of dysentery[55] which, especially in orangutans, may result fatally.

The majority of protozoologists who have studied the question have come to believe that the amoebae which are found living in certain of the water supplies of tropical and subtropical countries are saprophytic and of the free-living type.[56] Dobell[57] has insisted that the dysentery amoeba (*Entamoeba histolytica*) can not live and multiply outside of its human host and that it must always live at the expense of its host's tissues.

However, the recent investigations of Cutler[58] and particularly of Boeck,[59] who have both been able to cultivate *Entamoeba histolytica* in artificial media, the latter in one consisting of Ringer's solution, serum and egg media, obviously refute these assertions by Dobell that *Entomoeba histolytica* can not live and multiply outside of the human intestine.

As early as 1904 Musgrave[60] reported experiments in which cultures of saprophytic amoebae from hydrant water which were made upon a media containing merely agar, sodium chloride and extract of beef were fed to monkeys and produced amoebic dysentery in three of these animals. Another culture made on this same medium which was obtained from lettuce after the fourth washing in distilled water was fed to a monkey and produced amoebic dysentery in this animal, while another culture of the same amoeba when injected into the liver of a monkey produced amoebic liver abscess.

Franchini[61] has recently reported the production of liver abscess in two white mice out of a series of nine which were inoculated intraperitoneally with a culture of an amoeba isolated from latex of *Euphorbia*. However, these results have not been confirmed.

The cultures of *Entamoeba histolytica* obtained by Cutler and Boeck (*loc. cit.*) contained amoebae associated with bacteria. Musgrave, Lesage, Gauducheau[62] and others have also cultivated amoebae together with bacteria. All these amoebae were considered by the authors who reported the observations to be pathogenic under certain circumstances. It has often been suggested that bacteria are necessary for the growth and multiplication of amoebae and in addition that a symbiotic relationship exists between the amoebae and associated bacteria. Such a symbiosis, however, has not yet been satisfactorily demonstrated. However, it is well known that amoebae may exist in the intestine of man for long periods and, under certain circumstances, produce no lesions and no symptoms of intestinal disturbance, while under other circumstances, in association with these same amoebae, symptoms of dysentery and ulcerative lesions of the intestine result. Whether such a change in pathogenesis is inherent in or is developed in the amoebae is unknown. Possibly the presence and action of some lytic substance in the amoebae, but perhaps even formed by the host, and either acting primarily upon the amoebae or upon the intestinal walls may give rise to the production of the dysenteric symptoms and ulcerations of the intestine. Could a bacteriophagic agent be responsible for and exert such changes? Gauducheau believes that *Endolymax phagocytoides* is a parasitic species of the intestine of man and constitutes a form of passage between the *Entamoebae*

[55] Strong, "The clinical and pathological significance of B. coli." Bureau of Govt. Lab. Bull. No. 26, Manila, Dec. 1904.

[56] Strong, Billings—Forchheimer's Therapeusis of Internal Diseases, N. Y., 1924, III, 428.

[57] Dobell, "The Amoebae Living in Man," London, 1919.

[58] Cutler, *Jour. Path. & Bact.*, 1918, XXII, 22.

[59] Boeck, Proc. Amer. Soc. Trop. Med., 1924.

[60] Musgrave, Publications of Biol. Lab. Bureau of Sc., 1904.

[61] Franchini, *Bull. de la Soc. Path. Exot.*, 1923, XVI, 162.

[62] Gauducheau, *Bull. de la Soc. Path. Exot.*, 1922, XV, 229.

which are culturable with difficulty and the free-living amoebae.

Turning for a moment to organisms still more highly organized in the scale of life, we find many striking examples in the helminths of the efforts on the part of nature to perpetuate her species through the establishment of parasitism in which alternating and differently formed generations and cycles of development in intermediate hosts have resulted. From many of these examples it seems natural to conclude that the development of parasitism as well as of a change of host have been gradual transitions. Moniez[63] believes that all entozoa may be traced from saprophytes only a few of which have been able to settle directly in the intestine and there continue their development; these are forms such as *Trichocephalus, Ascaris* and *Oxyuris* which still lack an intermediate host. However, in many other cases the embryos consisted of such saprophytes as were in other respects suitable to become parasites, but were incapable of resisting the mechanical and chemical influences of the intestinal contents. They were, therefore, obliged, if they were to continue to exist, to leave the intestine and they accomplished this by penetrating the intestinal walls and burrowing into the tissues of their animal carriers. Later, by the ingestion for food, by beasts of prey, of some of these carriers, they passively reached the intestine of their new host and there, having become more capable of resistance, attained their maturity. By means of these incidental coincidences of various favorable circumstances these processes of parasitism, according to Moniez, have been gradually established. In the nematodes there are numerous examples of free-living members from which it seems probable that the parasitic species may be descended. Such examples are witnessed in *Leptodera, Rhabdonema* and *Strongyloides.* These mostly, if not exclusively, spend their lives in places where decomposing organic substances are present. Some species attain maturity only in such localities. Should the favorable conditions for feeding be changed, the animals may seek out other localities. It is understandable that such forms are very likely to adopt a parasitic manner of life which at first is facultative, as in *Leptodera* and *Anguillula,* but may be regarded as the transition to true parasitism. In many forms the young stages live free for some time, as in *Strongyloides;* in others, as in the case of *Rhabdonema,* parasitic and free-living generations alternate. A most striking example of a free-living (*Rhabditis*) generation passed in the soil, and a parasitic strongyloid, one which occurs in the intestine of man, is seen in *Strongyloides intestinalis.*[64] Infection of man occurs through penetration of the filariform larvae through the skin, in the manner of hookworm larvae, the embryo migrating through the lungs before becoming parasitic in the intestinal wall.

The genus *Aphelenchus* is of particular interest in that at least six of the species are recognized as pathogenic for plants—some causing serious agricultural pests. The genus comprises between thirty and forty species, the majority of which are free-living forms occurring in association with the roots of plants, in moist humus or in water. The two species known to be of most agricultural importance are *Aphelenchus fragariae,* Ritzema-Bos, 1891, and *Aphelenchus cocophilus,* Cobb, 1919. The former is endoparasitic in the stems of strawberry plants, where it causes hypertrophy and the production of "cauliflower" disease, or it may be ectoparasitic in the buds of the strawberry causing the "red plant disease." The latter (*Aphelenchus cocophilus*) occurs endoparasitically in the stem, leaf, and roots of the cocoanut palm, particularly in the West Indies and portions of Central America. "Red ring disease" of the cocoanut palm, also previously known as "Trinidad root disease," has been studied recently particularly by Nowell,[65] Cobb[66] and Zetek.[67] The diseased trees show a progressive yellowing and browning of the leaves commencing at the leaf-tip; the nuts are shed slightly in advance of the discoloration of the leaves and in a green condition, and this may be the first external evidence of the affection. On section the stem shows a well-marked complete ring of reddish-brown tissue, usually from one to one and a half inches in width and lying about from one to two inches from the periphery of the stalk. The diseased tissue may extend up the stem for several feet and then become broken into longitudinal streaks and irregular small patches. Leaf stalks may also show these same pathological changes. The roots become affected in the cortex, first undergoing yellowish or pinkish discoloration and softening, later becoming brownish red and sometimes dry and flaky. Infection experiments have been conducted by Nowell, Cobb and Zetek in which portions of diseased tissue containing the nematodes have been inserted into healthy palms with the result that the typical diseased conditions have been set up. The adult male and female nematodes occur abundantly in the roots in the areas where the tissues are softened and yellowish to brownish-red in color. The eggs are

[63] Moniez, "Trait de Parasit. Anim. et Veg.," Paris, 1896, 8vo.

[64] Strong, Johns Hopkins Hosp. Reports, 1902, X, No. III.

[65] Nowell, *West Indian Bull.,* 1919, XVII, 189.

[66] Cobb, *ibid.,* p. 203.

[67] Zetek, *U. S. Dept. of Agricul. Bull.,* No. 1232, 1924.

deposited in the tissues of the plant where they hatch out and the larvae invade fresh tissues. The larvae are found not only in the roots but also in enormous numbers throughout the diseased tissues. While the habits of these species outside the host plant have not been thoroughly studied, it seems reasonable to suppose that on the falling of diseased leaves or trunks the nematodes would ultimately find their way to the surface of the soil and the subjacent layers and that infection of the young plants might take place by the migration of the nematodes from the soil to the new plant. It has been shown that the nematodes will live in the soil about an infected palm. Very recently Zetek has made observations which have led him to suggest that the termite, *Coptotermes niger* (Snyder), may be a mechanical carrier of this nematode from the old host to the new plant, he having demonstrated nematodes clinging to the bodies of the termites which were living in a cocoanut palm infected with "red ring."

The writer has been able to study the disease in Panama and particularly in Spanish Honduras. While it would appear that the nematodes in question are certainly concerned in the production of the disease, the lesions produced in the palm consisting of the softening of the tissues, their liquefaction and subsequent necrosis, are not such as are usually attributed to nematodes. Both with the idea of acquiring information regarding the presence of some additional pathogenic agent in the disease and also of ascertaining any pathogenic action of the nematodes not only for the plant, but for animals, inoculations of suspensions of the nematodes in saline solution into mice, guinea pigs and rabbits were undertaken. The guinea pigs were inoculated intraperitoneally, subcutaneously or intraintestinally. The mice were inoculated subcutaneously and the rabbits intravenously or subcutaneously. When the injections were made intraperitoneally into guinea pigs the death of the animals often occurred in which there was a general peritonitis associated with a short bacillus, but no nematodes were found in the peritoneal fluid, the blood or other organs of the animal. In fact, after intraperitoneal inoculation the nematodes were never found alive in drops of fluid withdrawn by a capillary pipette from the abdominal cavity longer than two and one half hours after the time of the inoculation. In the guinea pigs which were inoculated by injecting the fluid containing the nematodes through the peritoneal cavity and walls of the intestines directly into the lumen, the nematodes were not subsequently found in the feces of the animal. Some of the rabbits which were inoculated intravenously also died, in which bacilli were isolated from the blood and liver, but no nematodes were found in these situations. In none of the experiments was any pathogenicity of the nematodes for these laboratory animals demonstrated. Cultures were made from the lesions of "red ring" after burning the surface of the palms and in practically all instances species of fungi or bacilli were cultivated. Much more extended observations must be made before we can conclude that the lesions of "red ring" are produced solely by *Aphelenchus*. Perhaps *Aphelenchus* may also carry mechanically bacteria with it into the tissues of the plant or offer a more favorable portal of entry for other microorganisms. Obviously, termites do not serve as the infective agent in many cases because in many cocoanut palms infected with "red ring" no infestation with termites is present. Therefore, in the case of *Aphelenchus*, so far as our knowledge goes, parasitism has apparently developed for plant rather than for animal life.

In conclusion it is obvious that I have but touched the fringe of this vast subject. However, it is my hope that this brief summary of some of the problems that have been elucidated and of some of those that still await solution may stimulate further research.

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UTILIZATION AND CONSERVATION OF THE TIMBER SUPPLY[1]

IN spite of the confusion of tongues and the tangle of comment, criticism and innuendo which always arise when attempts are made to fix the blame for the destruction of the country's timber supply, the principle that intelligent use of wood is one of the most effective forms of forest conservation has been gradually gaining the recognition it deserves. Acceptance of this principle implies belief in another, *viz.*, that the lumberman, the manufacturer, the retailer and the consumer are corporately responsible for securing from each piece of wood removed from the forest the greatest practicable quantity of service. The economics of good utilization are, however, but vaguely understood even by students of the subject; and the bearing of utilization on conservation is not appreciated at all by the millions most directly concerned.

One who investigates the pathological problems of wood conservation soon comes to realize that there is no such thing as a *normal* life of wood. He finds that fire and flood, wear and tear and breakage, neglect and plain carelessness are destroying an immense amount of wood every day in the year; he finds

[1] From the Office of Investigations in Forest Pathology, Bureau of Plant Industry in cooperation with the Forest Products Laboratory, United States Forest Service, Madison, Wisconsin.

insects and their relatives inflicting their evil share of damage; but he will be forced at last to the conclusion that the most important agents of wood destruction, either direct or indirect, are fungi. Fungous decay has reduced millions of cubic feet of our standing timber to rotten wood. In rough or finished material such as pulpwood, ties, poles or lumber the wood is subject to attack by fungi from the moment it is cut from the tree, and sooner or later practically all forest products which are not broken up or burned end their usefulness as a result of decay.

The loss which the country suffers annually from such decay can not be determined accurately, but one may estimate it roughly by combining data from various sources. In some cases the loss is directly indicated by the extension of service utility which results from preservative treatment. In other cases estimates are guesses, although they may be based on all the data available and adjusted as a result of personal observation.

In the accompanying table the figures showing loss from decay divide themselves into two groups. The first five types of material are necessarily destroyed in manufacturing processes for the sake of their derivatives—heat, wood pulp, wood distillates, tanning extract and excelsior. Loss in this group may be measured as a reduction in quantity or quality *of the derivatives*. In the rest of the classes the loss figures represent the amount of the annual cut needed to *replace* wood which has become unserviceable throughout the country on account of decay. The figures are believed to be conservative.

The loss figures mean, for instance, that one half the annual demand for poles results from the necessity of replacing rotten ones in the pole systems all over the country. The possible savings listed are estimates of the number of cubic feet which might be saved by proper handling and storage of material and by preservative treatment. Such measures would conceivably reduce the annual demand for poles by an amount equivalent to approximately fifteen and a half million cubic feet.

To the consumer, decay in forest products means more than the loss of the actual wood which has become rotten. It means replacement costs for lumber and labor, idle factory space and abortive attempts to use substitute materials in places where nothing can ever have the utility of wood. The individual purchaser bears most of the expense.

From the national viewpoint the cost of decay in forest products is the reduction of forest resources. The total annual growth of new wood which takes place on all the producing forests of the country is estimated at approximately 6,000,000,000 cubic feet. The loss figure at the bottom of column 3 in the table is nearly two thirds of this amount. The figure at the bottom of column 5, representing *preventable* decay, is approximately 30 per cent. of the total annual growth figure; and, for the present, at least, the difference between the totals of columns 3 and 5 must be considered unavoidable loss.

Our timber supply is like a reservoir which is fed by a small stream with an annual flow of six units. The outlet of the reservoir is discharging nearly

ESTIMATED ANNUAL LOSS RESULTING FROM DECAY IN FOREST PRODUCTS AND ESTIMATED POSSIBLE SAVING

Estimated quantity of timber removed from forests of the United States		Estimated annual loss from decay		Estimated annual possible saving (Preventable decay)	
Kind of Material	Equivalent in Standing Timber Cubic Feet	Equivalent in Standing Timber Cubic Feet	Approximate per cent.	Equivalent in Standing Timber Cubic Feet	Approximate per cent.
Fuel wood	9,500,000,000	712,500,000	7.5	237,500,000	2.5
Pulpwood	585,000,000	58,500,000	10.0	29,250,000	5.0
Distillation wood	133,000,000	9,975,000	7.5	6,650,000	5.0
Tanning extract wood	95,000,000	—	—	—	—
Excelsior wood	23,400,000	1,170,000	5.0	585,000	2.5
Lumber and dimension material	7,776,300,000	1,166,446,000	15.0	777,630,000	10.0
Ties, sawed and hewed	1,320,000,000	660,000,000	50.0	330,000,000	25.0
Fence posts	1,800,000,000	900,000,000	50.0	225,000,000	12.5
Mine timbers	395,550,000	79,110,000	20.0	59,333,000	15.0
Poles	55,250,000	27,625,000	50.0	15,470,000	28.0
Piling	39,000,000	9,750,000	25.0	4,875,000	12.5
Vehicle stock furniture, woodenware, handles, etc.	45,800,000	4,580,000	10.0	2,290,000	5.0
Cooperage	314,820,000	31,482,000	10.0	15,741,000	5.0
Shingles	198,000,000	29,700,000	15.0	19,800,000	10.0
Veneer logs	105,980,000	5,299,000	5.0	2,650,000	2.5
Export logs and hewed timber	18,400,000	—	—	—	—
Total	22,405,500,000	3,696,137,000	16.5	1,726,774,000	7.7

twenty-two and a half units a year. From the outlet stream certain rivulets are taking away four units, and of these more than one and seven tenths units are escaping through leaks which can and should be stopped up. Naturally the level of the reservoir is sinking. A series of new feeding streams (reforestation) will bring in additional units, slowly at first, and later more rapidly, and construction of the channels should be commenced at once. Meanwhile, however, the most effective means of slowing down the drain on the reservoir is to stop the leaks. In other words, stopping the leaks in utilization—cutting off the drain due to preventable decay—is one of the most effective single means of forest conservation. On the basis of the figures indicated, the stoppage if completely successful would amount to the same thing as increasing our producing forest area by 30 per cent.

The possible savings shown in the table can not, of course, be realized all at once. Effective changes in storage and handling methods are at best brought about slowly, for in many cases utilization depends on custom rather than scientific fact. Research has developed comparatively easy and extremely effective methods for preserving wood. Large organizations such as railroads and telephone or electric light companies can take advantage of the situation either by building wood-treating plants of their own or by arranging to have their ties or poles treated at commercial plants; but the individual householder has great difficulty—if indeed he succeeds at all—in securing enough treated lumber for his front porch. A certain amount of economic adjustment is necessary. It will surely come with a clearer understanding of the relation between proper use of timber and conservation of the forest.

REGINALD H. COLLEY

THE ROMANTIC AND IDEALISTIC APPEAL OF PHYSICS

THE bare facts, the ordinary sensations and common experiences in the daily life of the average physicist to-day, be he teacher or research worker, can certainly not be made to form an appeal to any man. Financially his lot is not a wealthy one nor socially is it high. This is just as true to-day as it was in the days of the dependent philosopher slaves of Greece or the roaming impecunious scholars of the Medieval and Dark ages. Yet even now in this modern age, where in America at least education is somewhat free from the influence, benevolent or otherwise, of wealth, church or patronage, we still find recruits in physics coming up to take the place of each one who is called away to higher realms of truth by death.

How can it be that the plain facts of life do not dismay the recently initiated, discourage discipleship and eventually cause the extinction of this element of our social system, the class of physics teachers and research physicists?

What can it be that as the world goes on and on its yearly passage of 400 millions of miles onward through space keeps and augments the faithful band of physicists?

Surely it must be some powerful force, soul gripping, that insensibly winds its tentacles around each likely nature-loving heart, never to release till death ends the all-absorbing efforts of that seeker after truth.

Solving the riddles of the universe, in a large way or a small, whatever might be his fortune, develops and comes to be the deep passion of the initiate into this profession. Close to nature and by it closer and closer every day to the Almighty God who made him, what matters it to the physicist if the days be dull or neighboring man uncouth? His soul is more or less aloof from mortal strife. The pangs, the torments, the hurts of common life lack their sting except insofar as they keep him from his teaching, his studies, his research.

The recompense of the physicist is not a worldly one at all. Therein lies reason for the eternal and the intangible nature of the appeal to him.

He realizes his reward with mental satisfaction as he feels his intellectual power over problems of nature. He keenly appreciates his mental growth and longs to tackle deeper and deeper problems of his existence and his world.

Though a sincere disciple of truth, he knows not how to express in words to others the strange influence that henceforth for him controls his destiny. And yet those of his students and his assistants most promising as future workers in this field of natural science feel the appeal through him. They can not help but follow eventually. No artificial call for recruits can have the power to select, hold and direct the same as that which of itself goes out from every true and sincere physics seeker after truth.

Dark discouragement and deep despair is sure to be the lot of every mortal man, particularly as he seeks to enter this realm of physics. Yet like the faith that lights the pilgrim's soul and carries him through the long and lonesome periods of trial and tribulation, just so there is a glow of hope that lasts until a steady purpose grips the soul of a new worker in our field.

To him who seeks to work in our domain we can not show success as judged by worldly standards, we can not say his road will be less hard and less long than ours. We certainly can not promise aught

that he can now appreciate. Indeed, we should state that he must leave worldly power and wealth behind.

We can assure him of our mental companionship and welcome him kindly to our midst as a coworker and coseeker after truth. The inspiration to come closer to the soul of things and understand, we are convinced, is likely to be his as much as ours. Surely this is an opportunity as privileged, as wonderful as any offered by other professions. What other than physics will give that development, real and splendid, of the human mind, or that ability of unfolding and of interpreting to fellow-man the things we have personally gleaned from the all-present nature, the visions our inspiration affords us at times of seeing more wonderful and strange phenomena in this interesting universe around us.

The beginner finds that the road is rough and long, but somehow when needed the financial means arise to carry the persistent investigator through the university over into this new realm of romance and idealism. When he arrives his recompense will be the pleasure of pioneering into the frontier-land of unsolved things, dissipating the mists of darkness, in pushing back the clouds of ignorance and bringing new areas of nature into subjection for the service of mankind.

What a world of romance and idealism awaits the loyal and faithful? This is verified by the interesting biographies of all leading physicists. Wonderful problems of physical science await to enthrall him in every advanced line of human endeavor. Their abundance and their interest knows no end.

He who has not been moved by these things can not understand. It needs a willing and experienced mind. The standards of measuring success are not invariable ones and so he can not estimate and pass judgment on the net returns for us in this new world of science. From the world's point of view it may rightly be considered as a foolish pursuit and a sad illusion. The explorer, the ambassador and the missionary, however, all experience more in life than most people realize and so it goes in this. There is an appeal that grips the soul. There develops and persists a love for the work that never dies while we live. The pride of attainment, the joy of accomplishment of work planned, the happiness of imparting knowledge to others and the kindly communion with similarly inclined minds, all these constitute some portion of the physicist's reward.

Moreover, the soul is probably more nearly satisfied in this profession than in any other activity that man may follow. For in choice moments his soul, he is convinced, thereby abides in fellowship with all that is worth while in life, and at those rare periods of the highest inspiration his ego, his own true self, will walk in communion with his God.

What more can sincere man desire?

PHYSICS DEPARTMENT, RICHARD HAMER
UNIVERSITY OF PITTSBURGH

SCIENTIFIC EVENTS

SIR WILLIAM OSLER MEMORIAL

THE memorial volume now being published under the auspices of the International Association of Medical Museums comprises a large series of personal and biographical articles reminiscent of the life and activities of the late Sir William Osler during the different periods of his career, written by intimate friends and associates. This was primarily intended as a contribution, from first-hand evidence, to our knowledge of those early cultural influences and biological and pathological researches which militated so largely to his development as a leading teacher and master of clinical medicine; but it has been extended through numerous valuable contributions received, to cover all phases of his many-sided life. The scope and plan of the work are outlined in introductory articles by Sir Clifford Allbutt and Professor William H. Welch, and it is completed by a classified bibliography of Sir William Osler's publications (based on the chronological bibliography by Miss M. W. Blogg), and by a bibliography of "Writings about Osler."

The volume will contain over sixty illustrations, both photogravure engravings and half-tone prints. The edition is being privately issued by subscriptions to the volume paid in advance, and, with the aid of a publication fund which was inaugurated in January, 1921, by generous initial contributions from the National Research Council of Washington, the late Sir Edmund Osler and the late Honorable Mr. Justice Featherstone Osler (brothers of Sir William Osler), Mrs. K. S. Reford, of Montreal, and Mr. J. J. Carty, of New York.

Following is a list of the contributors to the volume to date:

Frontispiece: From a photograph presented by Lady Osler for publication in this volume.

Editorials and General Articles: Sir T. Clifford Allbutt, Cambridge (*Pro-em*); William H. Welch, Baltimore (*Foreword*); Maude E. Abbott, Montreal; J. George Adami, Liverpool; C. N. B. Camac, New York; Henry W. Cattell, Washington; W. W. Francis, Oxford; Fielding H. Garrison, Washington; Henry Barton Jacobs, Baltimore; Sir Arthur Keith, London; O. Klotz, Toronto; Leonard L. Mackall, Savannah; Charles F. Martin, Montreal; Pierre Marie, Paris; Thomas McCrae, Philadelphia; Joseph Pratt, Boston; L. J. Rhea, Montreal; Sir Seymour Sharkey, London; A. S. Warthin, Ann Arbor; Sir German Sims Woodhead, Cambridge.

Early Years and Montreal Period: N. B. Gwyn, J. L. Todd, Marian Osborne, F. J. Shepherd, A. D. Blackader, E. J. A. Rogers, G. E. Armstrong, Casey A. Wood, J. B. Lawford, Murdoch Chisholm, J. Herbert Darey, R. F. Ruttan, A. Schmidt, E. Weir Smith, Maude E. Abbott.

Philadelphia Period: C. K. Mills, R. H. M. Landis, E. B. Krumbhaar, George Dock, Hobart A. Hare, Joseph Leidy, 2d, William A. Edwards, F. X. Dercum, Charles W. Burr, Morris J. Lewis, A. C. Wood, H. M. Toulmin, J. C. Wilson, David Riesman.

Baltimore Period: Howard A. Kelly, Llewellys F. Barker, Henry M. Hurd, T. R. Brown, H. A. Lafleur, John T. Finney, Charles P. Emerson, W. S. Thayer, C. D. Parfitt, Huntington Williams, A. C. Abbott, Hunter Robb, H. E. Robertson, L. J. Rhea, Helen MacMurchy, D. S. Lamb, George Blumer, Rufus Cole, J. G. Clark, Adolphus Knopf, Marcia C. Noyes, Esther Rosencrantz.

English Period: Sir Humphrey Rolleston, Sir William Hale-White, F. Parkes Weber, William Collier, Archibald Malloch, A. G. Gibson, Henry Viets, Wilburt Davison, Wilder Penfield, Walter Bierring, R. Tait MacKenzie, E. C. Streeter, Charles Singer, H. S. Birkett, C. A. P. Howard, J. G. Adami, Stewart Roberts.

Classified Bibliography. Edited by Fielding H. Garrison and Henry W. Cattell.

Bibliography of "Writings About Osler."

THE WHIPPOORWILL EXPEDITION

DURING the summer and autumn of 1924 the United States Navy provided the U. S. S. *Whippoorwill* for a scientific survey of five Pacific islands lying near the equator. The ship was assigned to the National Research Council, under a cooperative arrangement whereby the officers of the navy assumed responsibility for collecting and charting hydrographic data, and the Research Council, acting through the Bishop Museum, of Honolulu, furnished the scientific equipment and personnel. Because of his familiarity with the difficult conditions of navigation among uncharted coral reefs, Commander S. W. King was chosen as representative of the navy in charge of the expedition. He was ably assisted by Captain W. J. Poland and the other officers of the *Whippoorwill.*

To replenish fuel and stores and to permit substitutions in the scientific staff, the expedition arranged two trips each starting from Honolulu. For Trip A, planned for a study of Washington, Christmas and Jarvis islands with their intervening waters and reefs, the civilian scientific personnel consisted of Professor C. H. Edmondson, zoologist, chief of party; Professor Herbert Bergeman and Dr. Erling Christophersen, botanists; Dr. C. K. Wentworth, geologist; A. L. Whitney, entomologist; Theodore Dranga, marine conchologist; John Baker, Harry E. Cory and Theodore Waters, collectors. For Trip B, designed for a survey of the remote islands Howland and Baker, the scientific staff was: Dr. C. Montague Cooke, zoologist, chief of party; Dr. T. A. Jaggar, geologist; Dr. Erling Christophersen, botanist; Dr. Edward L. Caum, entomologist; W. C. Ramsey, meteorologist; Bruce Cartwright, archeologist; George W. Collins, topographer; George C. Munro, ornithologist; Theodore Dranga, marine conchologist; Theodore Cooke, zoological collector.

From all the islands visited large collections of plants, insects, birds, fish, mollusks and other forms of marine life were obtained and are being distributed to specialists for study. The islands and reefs were mapped and special studies made of the relation of soil to vegetation, of raised beaches and of air currents. The archeological remains on Howland Island are unlike those so far found elsewhere.

The *Whippoorwill* Expedition is essentially a continuation of the Tanager Expedition (see annual report of the director of Bishop Museum for 1923). Both were made possible by the generous cooperation of the navy, and they have resulted in procuring material for a number of papers on the botany, archeology, geology and zoology of twenty islands about which little had previously been known.

ANNUAL MEETING OF AMERICAN CERAMIC SOCIETY

THE annual meeting of the American Ceramic Society for 1925 will be held at Ohio State University, from February 16 to 21, in connection with the national celebration of the thirtieth anniversary of the beginning of ceramic education in America.

An exhibit of equipment and materials will be shown in Lord Hall and the ceramic manufacturers are exhibiting products in the new museum building of the Ohio Historical and Archeological Association.

The university has invited all the ten universities having ceramic departments to participate in the celebration. The ceramic trade associations are sending delegates. Each of them has kept this week free of other engagements so as to make this occasion national in character and representative of all ceramic enterprises, manufacturing, research and education. The Ohio manufacturers are planning plant itineraries for each of the divisions which will profit all who will participate.

An outline of the preliminary program for the celebration follows:

FEBRUARY 16

Morning Session—10:00 A. M.—Address of welcome, President W. O. Thompson.

"The founding of the first ceramic school," Dr. Edw. Orton, Jr.

"Thirty years' progress in ceramic education," A. V. Bleininger.

"The future of ceramic education," Dr. Edward R. Weidlein.

Afternoon Session—2:00 P. M.—"The value and possibilities of ceramic education to the craftsman," Professor Chas. F. Binns.

"The early stages of the science of ceramics in America," Karl Langenbeck.

"Outstanding achievements during thirty years in the different ceramic fields" (presented as lantern slides): art, enamels, glass, heavy clay products, refractories, terra cotta, whiteware.

"The development of ceramic education in America by the different ceramic schools" (presented as lantern slides).

"Statistical analysis," an address by R. D. Landrum, president American Ceramic Society.

Business session.

Evening Program—8:00 P. M.—Reception of presidents and representatives of ceramic schools.

8:30 P. M.—Stunt program by students of Ohio State University, Armory.

9:30 P. M.—Dancing until midnight.

The following four days will be devoted to scientific sessions for the reading of papers. A full program has been prepared for each of the following divisions of the society: The art division; the enamel division; the heavy clay division; the glass division; the white ware division, and the refractories division. There will also be a casting colloquium at which a number of questions relating to casting will be discussed.

PUBLIC LECTURES AT THE HARVARD MEDICAL SCHOOL

THE faculty of medicine of Harvard University announces a course of free public lectures on medical subjects, to be given at the Medical School, Longwood Avenue, on Sunday afternoons, beginning February 1 and ending April 26. These lectures will begin at four o'clock and the doors will be closed five minutes past the hour. No tickets will be required.

The lectures will be as follows:

February 1—Dr. Percy R. Howe, "Is diet a factor in dental disease?"

February 8—Dr. Walter B. Cannon, "Some factors affecting growth."

February 15—Dr. Cecil K. Drinker, "Gas poisoning and electric shock with a demonstration of treatment."

February 22—Dr. Edwin H. Place, "The conquest of the contagious diseases."

March 1—Dr. Francis W. Palfrey, "The family medicine closet."

March 8—Dr. William E. Ladd, "Abdominal surgery in childhood."

March 15—Dr. Elliott P. Joslin, "Diabetes: how to avoid it; how to live long with it."

March 22—Dr. William H. Robey, "The hygiene of the heart."

March 29—Dr. William C. Quinby, "Disturbances of urination in men" (to men only).

April 5—Dr. C. Macfie Campbell, "Belief and delusion."

April 12—Easter Sunday, no lecture.

April 19—Mr. Norman W. Fradd, "Posture, exercise and health."

April 26—Dr. Franklin S. Newell, "Modern obstetrics" (to women only).

SCIENTIFIC NOTES AND NEWS

THE executive committee of the Pacific Division of the American Association for the Advancement of Science announces that the 1925 meeting of the division will be held from June 17 to 20, at Reed College, Portland, Oregon. It is expected that most of the twenty-seven societies affiliated with the Pacific Division will meet at the same time and place. The general and special programs are now in preparation and will be announced in due time.

DR. LOUIS A. BAUER, director of the department of terrestrial magnetism of the Carnegie Institution of Washington, has been elected corresponding member of the Russian Academy of Sciences.

DR. VERNON KELLOGG, of the National Research Council, has been elected president of the Washington Academy of Sciences for 1925.

JOHN F. STEVENS, of New York City, has been awarded the John Fritz Gold Medal of the Engineering Foundation, New York, "for great achievements as a civil engineer, particularly in planning and organizing for the construction of the Panama Canal, as a builder of railroads and as administrator of the Chinese Eastern Railway."

THE Eunice Rockwood Oberly Memorial Prize, awarded every two years for the best original bibliography in the field of agriculture or the natural sciences, will be awarded to Max Meisel, of New York, for the first volume of his "Bibliography on American Natural History."

DR. JOHANNES BUTTIKOFER, director of the Zoological Garden at Rotterdam, has been elected a foreign member of the Zoological Society of London.

DR. LUDWIG ASCHOFF, of the University of Berlin, who delivered lectures at several medical colleges in Japan this fall, has been elected honorary president of the Japan Pathological Association.

AT the Centenary celebration in Copenhagen, of the Society for the Spread of Natural Philosophy, the Danish physicist, Niels Bohr, was presented with the Oersted gold medal of the society.

THE Lamarck Prize (zoology), of the Royal Academy of Belgium, has been awarded to Professor E.

Chatton, professor of general biology in the University of Strasbourg.

THE Ernst-Abbé Prize, founded in 1921, by Carl Zeiss, for the furtherance of mathematics and physics, has been awarded to Professor Felix Klein, of the University of Göttingen, for his work in mathematics.

THE following have been elected officers of the Cambridge Philosophical Society for the session 1924–1925: *President,* Professor J. T. Wilson; *vice-presidents,* Professor J. Barcroft, Mr. C. T. Heycock, Dr. G. T. Bennett; *treasurer,* Mr. F. A. Potts; *secretaries,* Dr. F. W. Aston, Mr. J. Gray, Mr. F. P. White; *new members of the council,* Dr. A. B. Appleton, Dr. C. D. Ellis, Mr. F. F. Blackman, Mr. C. T. R. Wilson, Mr. J. E. Littlewood, Mr. G. Udny Yule, Professor E. A. Milne.

DR. HAROLD LEE ALDEN, assistant professor of astronomy at the University of Virginia and research assistant of the Leander McCormick Observatory, has accepted an offer from Yale University to go to South Africa as director of the new observatory being established there.

DR. KARL F. KELLERMAN, who has been in direct charge of the *Journal of Agricultural Research* since that publication was started in 1913, recently resigned from that work. Dr. E. W. Allen, chief of the office of Experiment Stations, was thereupon appointed chairman of the joint editorial committee of the journal and Dr. C. L. Shear was appointed to fill the vacancy on the committee.

DR. M. C. MERRILL, director of forestry publications of the United States Forest Service, has been appointed assistant director of publications in charge of scientific and technical manuscripts of the United States Department of Agriculture. As part of his duties he will have editorial supervision of the *Journal of Agricultural Research* in cooperation with the editorial committee of six representing the Department of Agriculture and the Association of Land Grant Colleges.

DR. CHARLES PACKARD, formerly assistant professor of biology in the Peking Union Medical College, has been appointed associate in zoology in the Institute of Cancer Research of Columbia University.

DR. JOHN B. WATSON, of the J. Walter Thompson Co., has been made a vice-president of the company.

DR. GEORGE K. PRATT, medical director of the Massachusetts Society for Mental Hygiene, has announced his resignation from that organization to become assistant medical director of the National Committee for Mental Hygiene in New York City.

DR. HARRY A. CURTIS has accepted a consulting appointment on the staff of the Fixed Nitrogen Research Laboratory and has been assigned to the office of the director of scientific work of the Department of Agriculture.

DR. E. D. BOTTS, assistant professor of chemistry at the University of Louisville, has been appointed research chemist with the American Marine Paint Co., San Francisco.

JOSEPH S. REICHERT has resigned his position as professor of chemistry at the University of Notre Dame to accept a position as chemist in the anti-gas department of the Chemical Warfare Service, Edgewood Arsenal.

DR. H. H. KNIGHT, assistant professor of entomology at the University of Minnesota, has accepted an appointment as assistant professor of entomology at the Iowa State College.

THE Board of Regents of the University of Minnesota have granted Professor F. L. Washburn, of the department of entomology, a year's leave of absence to collect insects in islands of the South Pacific not visited by him on a previous expedition, two years ago. It is planned to make collection on certain isolated islands of the Society group, and also in the Tuamotu Archipelago, consisting of over seventy atolls lying east of Tahiti, and formerly called the Paumotus.

FREDERICK G. CLAPP has completed his investigations in Western Australia, finding among other things a new tillite locality and some previously unknown fossil localities. He has gone to New Zealand.

THE total eclipse of the sun on January 24 was observed by Richard Schorr, director of Hamburg University Observatory, and Professor Baade, from the steamship *Liguria,* bound for Philadelphia. The ship offered the astronomers all facilities for the observations.

DR. EDWARD L. THORNDIKE, professor of educational psychology at Teachers College, Columbia University, gave a series of six lectures during the week of December 8 to 13, at the University of Minnesota.

DR. WILLIAM MANSFIELD CLARK, professor of chemistry at the Hygienic Laboratory, Washington, addressed the scientific staff of the Rockefeller Institute for Medical Research, on January 23, on "Oxidation-reduction indicators."

DR. E. P. MATHEWSON, president of the American Institute of Mining and Metallurgical Engineers, on January 20 gave a lecture on "The influence of research in scientific metallurgy," before the Columbia University Chapter of the Sigma Xi.

ON January 10, Dr. Lewellys F. Barker, of Baltimore, delivered an address to the Royal Canadian Institute on the subject "The prevention of nervous breakdown."

AT the invitation of the University of Wisconsin, Dr. Aleš Hrdlička delivered three lectures at the university, on January 12, 13 and 14, on "Human origin and evolution." On January 16 he also delivered a lecture on "Some newer aspects of human evolution," before the Anthropological Society of St. Louis.

A BRONZE memorial plaque of the late Sir William Osler, formerly physician-in-chief of the Johns Hopkins Hospital, has been presented to the Johns Hopkins Historical Club by a group of his former associates and friends.

DR. BURT G. WILDER, emeritus professor of neurology and vertebrate zoology in Cornell University, died on January 21, in his eighty-fourth year.

DR. DAVID GREGG METHENY, professor of anatomy and histology in Temple University, Philadelphia, and curator of the anatomical museum of the Woman's Medical College of Pennsylvania, died on December 15, aged fifty-one years.

DR. NORMAN BRIDGE, emeritus professor of medicine at Rush Medical College, Chicago, died on January 10, in his eightieth year.

DR. ERNST BUMM, professor of gynecology at the University of Berlin, and author of a standard work on obstetrics, has died, aged sixty-seven years.

DR. KASTNER, curator and assistant at the Anatomical Institute of the University of Leipzig, has died.

THE Society of American Bacteriologists has elected the following officers for 1925: *President,* Norman MacL. Harris, Department of Health, Ottawa, Canada; *vice-president,* Hans Zinser, Harvard University Medical School, Boston, Massachusetts; *secretary-treasurer,* James M. Sherman, Cornell University, Ithaca, N. Y.; *councilors at large,* Charles C. Bass, Edwin B. Fred, Ivan C. Hall, Karl F. Meyer.

AT the annual meeting of the American Society for Experimental Pathology, December 29, Washington, D. C., the following officers were elected: *President,* Dr. George H. Whipple, Rochester, N. Y.; *vice-president,* Dr. Wade Hampton Brown, New York, and *secretary-treasurer,* Dr. Edward B. Krumbhaar, Philadelphia.

AT the annual meeting of the Washington, D. C., chapter of the American Institute of Chemists held on January 9, the following officers were elected for the ensuing year: *President,* James F. Couch, Bureau of Animal Industry; *vice-president,* Dr. Harrison E. Patten, consulting chemist; *secretary,* J. N. Taylor, Bureau of Animal Industry; *treasurer,* Dr. H. L. Lourie, U. S. Tariff Commission. Dr. Charles E. Munroe was elected honorary president.

THE 912th meeting of the Philosophical Society of Washington was held in the Cosmos Club Auditorium, on January 24. The program was made up of reports of the Madrid meeting of the International Geodetic and Geophysical Union; a general report and report on the section of seismology was given by Professor Harry Fielding Reid, Johns Hopkins University; a report on the section of geodesy by Major Wm. Bowie, Coast and Geodetic Survey; a report on the section of meteorology by Dr. H. H. Kimball, Weather Bureau, and a report on the section of terrestrial magnetism by Dr. L. A. Bauer, Department of Terrestrial Magnetism.

THE date for the first Oil and Gas Power Week has been set for April 20 to 25. The week will be celebrated by technical meetings to be held in selected cities throughout the country—at least 25 in number. Industrial plants in the selected communities will be asked to cooperate. Topics to be studied during the week will be the use of the Diesel engines in central stations, industrial plants and on shipboard, methods of testing oil and gas engines, and problems in design, weight reduction, operating costs, etc. Cooperating with The American Society of Mechanical Engineers in plans for the week are the following organizations: National Association of Stationary Engineers; American Society of Marine Engineers, American Chemical Society, American Society of Naval Engineers, National Safety Council, American Society of Agricultural Engineers, U. S. Chamber of Commerce, Society of Naval Architects and Marine Engineers, U. S. Bureau of Mines and the U. S. Department of Commerce.

ACCORDING to the *Journal* of the American Medical Association, the British Sanitary Services which deal with prevention of disease and research in the British army have been reorganized. There is now at the war office a directorate of hygiene which comprises a director and an assistant director, whose duties are to collect information concerning prevailing diseases, water supplies, geology and climate in possible theaters of war and to formulate suitable hygienic measures; to direct courses of training for the school of hygiene and for the sanitary personnel; to look after medical questions in connection with recruiting, housing, camps, hospitals and barracks, the collection and purification of water supplies, disinfectants and technical questions concerning food, clothing and equipment. There has been created also

a directorate of pathology, comprising a director and an assistant director. They are concerned with (1) general questions in pathology, bacteriology and tropical medicine; (2) pathologic questions concerning the prevention and treatment of diseases, injuries and wounds, and the initiation of research in pathology in matters relating to the health of the army; (3) the general direction of the work of pathologists at home and abroad; (4) technical questions relating to the preparation and use of serums and vaccines; (5) matters relating to the control of venereal disease, and (6) medical problems connected with gas warfare. These directorates are under the director-general of the army medical services. Deputy assistant directors of hygiene and pathology are allotted to various districts and they advise the assistant directors on technical questions.

AN award, to be known as the Wright Brothers Medal and to be given each year for the most meritorious contribution to aeronautical science, has been instituted by the Dayton Section of the American Society of Automobile Engineers, to commemorate the pioneer aeronautical achievements of the Wright brothers. Papers sent in for the purpose of the award must be plainly labelled with the author's name and address and forwarded to the Wright Brothers Medal Committee, Dayton Section, S. A. E., care of the Engineers Club of Dayton. The award committee will be appointed annually by the section contest committee, and for next year will consist of Professor E. P. Warner, Massachusetts Institute of Technology; H. M. Crane, president, American Society of Automotive Engineers, and, in addition, an aeroplane designer and a test pilot, to be chosen later. The award for 1924 will be based on papers received up to December 31, 1924.

ACCORDING to the *Journal* of the American Medical Association the subsidy paid by the Japanese government to encourage scientific research amounts to a total of 135,000 yen for the present fiscal year. It has been awarded to about eighty research workers in fifteen medical colleges, seven special schools of medicine, pharmacology and dentistry and three institutes. Among those receiving awards and their subjects are, Dr. Takagi, "Prophylaxis of typhoid fever and dysentery with special reference to food and drink"; Dr. Matsuo, "Functions of the liver"; Professor Awoki, "The immunologic classification of bacilli"; Professor Ishihara, "Function of the system of stimulative conduction of the heart"; Professor Fukushi, "Studies on thyroid gland"; Professor Okada, "Studies on the basal metabolism and nourishment"; Professor Manabe, "Studies on caisson disease."

RECENT acquisitions at the Natural History Museum, London, include a bequest by the late Mr. Philip Roscoe, of over 5,000 specimens of lower carboniferous fossils collected by Mr. Roscoe in Derbyshire, Staffordshire and Yorkshire. These form a valuable addition to the museum collection and are contained in five large and well-made cases which in themselves would be of great service to the museum. Lord Leverhulme has presented a complete skull, lower jaw and baleen of both sides of a female fin whale. This specimen, which weighs between five and six tons, was received at the museum in one large case. A number of purchases have been made, including a skull of the prehistoric rhinoceros *Elasmotherium sibiricum* from Siberia. Skulls of this rhinoceros are exceedingly rare, and the only specimen comparable with this one is in Leningrad. Another important purchase is that of a crystal of Olivine (Peridot) of gem quality from the island of St. John, in the Red Sea. The crystal weighs 137 grams, of 685 carats, and is the largest hitherto found. The other purchases include a selection of minerals, comprising 195 specimens, from the United States; nearly 3,000 specimens of flowering plants and cryptogams from the Philippine Islands; 202 bird skins from Cameroon; two casts of South African bushmen, a male and a female, and 210 fossil sponges from southern Germany. Casts have been received by exchange from the American Museum of Natural History of the fossilized dinosaur eggs discovered by the expedition sent by that museum to Mongolia.

UNDER the auspices of the United States Bureau of Fisheries, the *Halcyon* completed three cruises during July and August, tagging about 1,500 fish on Nantucket Shoals and 1,800 off the coast of Maine. The tagged fish consisted of 75 per cent. cod, 20 per cent. haddock and 7 per cent. pollock. The *Halcyon* recaptured 10 and other fishermen three of these fish up to August 28, 1924. The number of recaptured fish recorded from the 10,246 tagged during 1923 now numbers 245. During the present month one vessel fishing in South Channel, Mass., recaptured eight tagged fish, of which six belonged to the 1923 class and two to the 1924 group. Fishing on Nantucket Shoals in July, 1924, the *Halcyon* recaptured 10 tagged fish that had been tagged in the same locality during the following months of 1923: One in May, one in June, one in August, one in September and six in October. These fish were carefully remeasured and the data obtained on the rate of growth have proved of great interest. The *Halcyon* plans to continue fish-tagging throughout September and October, operating on Nantucket Shoals and along the coast of Maine. In order to obtain a large amount of data on the age of the fish with respect to length, scales have been taken from every fish caught during the present year. Be-

cause of the wide range in the size of the fish, 10¾ to 54 inches, this material will prove of unusual value.

THE British government has decided to proceed at once with certain preliminary investigations in order to ascertain the feasibility of the scheme for using the tidal power of the River Severn for the production of electrical energy by the erection of a barrage across the river. The work has been entrusted to the Department of Scientific and Industrial Research, and the president has appointed a committee, constituted as follows, to control the operations: Mr. G. S. Albright, *chairman*; Professor A. H. Gibson, Mr. G. W. Lamplugh, Mr. Maurice Wilson and Dr. J. S. Flett, director of the Geological Survey and Museum. The feasibility of the Severn scheme depends upon the possibility of finding satisfactory foundations for a barrage. Accordingly the first stage of the investigation will involve: (*a*) The study by the Geological Survey of the stratigraphical formations in the neighborhood of the sites suggested for the erection of the barrage; (*b*) preliminary soundings with a view to determining the contour of the river bed at the sites; and (*c*) preliminary measurements of the flow of water at different states of the tide. The cost of the investigations is estimated at £95,000. Sir Maurice Fitzmaurice and Sir John Purser Griffith have been invited to submit a joint report before the end of this year as to the possibility of constructing a barrage on one or more of the sites suggested on the assumption that safe foundations exist. The data which will be provided as a result of the geological and hydrographical investigations will be placed at their disposal. The staff of the Geological Survey has already begun the inquiry.

THE complete investigation of personal health records extending back through several generations and covering a whole nation has been undertaken by the Swedish Institute of Racial Biology, which, according to the *Medical Journal and Record,* has turned in the report of the second year of its work. Under Professor H. Lundberg, who organized the institute, anthropological statistics have now been gathered concerning 83,427 persons. Stature, head measurements, colors of eyes and hair, diseases, especially hereditary diseases, causes of death, etc., are among the things observed by the investigators. In the northern provinces of Sweden, where Lapps, Finns and Swedes have intermarried, the death rate is relatively high. Special genealogical studies have, therefore, been undertaken in this region in order to ascertain, if possible, what effect race mixture has on longevity. In three villages, for example, genealogical histories have been drawn up for the entire population covering a period of 125 years. In another community the histories of 1,200 families have been traced during the period of 1781–1851. The accumulation of data regarding hereditary disease, the development of criminal instincts and other traits is only a part of the program of the Swedish Institute of Racial Biology. It is also conducting research work into the elimination of racial taints through eugenic measures. Research is also being directed into the field of eugenics and the development of individual talent and genius.

ONE of the largest research organizations ever developed for the study of synthetic resins will be housed in the new laboratory of the Bakelite Corporation now nearing completion at Bloomfield, N. J. The building is two stories high and approximately 50 feet by 110 feet in size. Present plans are for accommodations to take care of twenty-five research workers. Major problems of raw material production, improvement and modification of synthetic resin compounds and of general commercial development will be handled.

UNIVERSITY AND EDUCATIONAL NOTES

JOHN D. ROCKEFELLER, JR., has donated the sum of $1,600,000 to the Imperial University of Tokio, Japan, to restore the library which was destroyed in the earthquake and fire of 1923.

COLGATE UNIVERSITY has received a gift of $400,000 from Austen Colgate, of Orange, N. J., which brings its alumni fund to $945,000.

DARTMOUTH COLLEGE has received from George F. Baker, of New York, a gift of $100,000 for the establishment of a special endowment fund in memory of his uncle.

THE will of Mary P. C. Nash, widow of Bennett Hubbard Nash, for many years professor of modern languages at Harvard University, leaves her residence and $30,000 to the university to establish three trusts.

ROSCOE POUND, dean of the Harvard Law School, has been elected president of the University of Wisconsin, in the place of President E. A. Birge, who will retire at the end of the present academic year.

PROFESSOR CHARLES A. HOLDEN has resigned as director of the Thayer School of Civil Engineering at Dartmouth College, to take effect at the close of the present academic year.

DR. LAWRENCE LA FORGE, of the United States Geological Survey, has been chosen to conduct two courses in geology at Harvard University, during the second half year, owing to the absence of Professor J. B. Woodworth.

DR. CHARLES PHILLIPS, formerly professor of

pathology at Wake Forest College School of Medicine, has been appointed professor of pathology at the Medical College of Virginia, Richmond.

DR. ALBERT BACHEM has been appointed professor of radiology and director of the laboratory at the University of Illinois College of Medicine, Chicago.

DR. HOMER G. BISHOP, instructor in psychology at Cornell University, has been appointed assistant professor of psychology at Smith College.

PROFESSOR HANS SPEMANN, of the University of Freiberg, has been called to the chair of zoology at the University of Berlin, to take the place of Professor Heider, who has been made professor emeritus.

DISCUSSION AND CORRESPONDENCE

A NOTE ON THE SURFACE VISCOSITY OF COLLOIDAL SOLUTIONS[1]

THE excellent paper by R. E. Wilson and E. D. Ries on "Surface films and plastic solids" (Colloid Symposium Monographs, 1923) encourages me to publish the results of preliminary experiments made in 1922, before I had heard of Messrs. Wilson's and Ries's work, which are in complete accordance with their results.

The method I used differed from theirs. They employed a torsion pendulum, the polar moment of inertia of which was equal to 485 gr cm², and a circular glass plate, 3.8 cm in diameter, in contact with the liquid. I used a slightly more elaborate but, I believe, more sensitive instrument. A small glass rod, 0.4 mm in diameter and 10 mm long, was suspended to a galvanometer wire (Leeds and Northrup rolled phosphor bronze, 0.000125 cm thick = 0.002 inch); a mirror permitted the readings on a scale, and a light damping device provided a steady spot. The instrument itself was the micro-viscometer described previously.[2] Instead of having the liquid rotated continuously by means of the constant speed motor, it was only rotated by one twelfth of one revolution (30 degrees), or even one thirty-sixth of one revolution (10 degrees), in one minute exactly. The shearing stress was thus very small, and could be decreased at will. The first measurement was made as soon as the solution was poured into the rotating vessel. The other measurements were made with the same solution after a certain number of minutes had elapsed. Hence, the slow building up of the adsorbed layer could be followed. Unfortunately, I had no time to continue this work, and made only a few experiments, one of which follows:

VARIATIONS IN FUNCTION OF THE TIME OF THE SURFACE VISCOSITY OF A SERUM SOLUTION AT 1/10,000
TEMPERATURE = 22° C.

Time in minutes.	0	7	10	15	30	50	90
Readings (proportional to the viscosity).	0	27	40	55	104	170	284

When plotted on paper, the curve shows a very slight upward convexity. After 1½ hours, the surface rigidity is considerable, despite the fact that the thickness of the adsorbed layer is only 41×10^{-8} cm, as I have shown in a preceding paper,[2] and that this is probably the mean value of the length of the individual protein molecules present in a serum solution.

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NUMBER OF UNITED STATES SCIENTISTS WHEN THE SIGMA XI SOCIETY WAS FOUNDED

THE question has arisen as to what need there was in 1886, when the Sigma Xi Society was founded, for this organization of "companions in zealous research." Was the United States not contributing at that time its full share to the advancement of science?

To find an approximate answer to this question, a brief analytical study was undertaken, based upon the third volume of Poggendorff's Handwörterbuch, which gives the names of research men and the titles of their papers in the exact sciences throughout the world for the 25 years from 1858 to 1883. This is the period immediately preceding the founding of the Sigma Xi. I classified the scientists listed in Poggendorff by countries. As the volume covers over 1,400 pages, I took only part of the volume, namely, the first 15 pages of every 100 pages, and then multiplied the figures thus obtained by 6⅔.

On the basis of the data thus secured, the distribution of scientists over the ten leading countries, for the period 1858 to 1883, was as follows: Austria-Hungary 560, England 633, France 707, Germany, 1,927, Holland 207, Italy 280, Russia 340, Sweden 193, Switzerland 220, the United States 447. In this list Germany stands first with 1,927, and the United States fifth with 447 scientists.

But this mode of comparison is not quite fair; the populations of the various countries should receive consideration. Accordingly, we computed the number of scientists (for the period 1858–1883) for every million of population based on statistics of 1870. Per million of population, Austria-Hungary had 15¾ scientists, England 20, France 19½, Germany 47, Hol-

[1] From the laboratories of The Rockefeller Institute for Medical Research.

[2] du Noüy, P. L., *J. Gen. Physiol.*, 1919, i, 521.

[3] du Noüy, P. L., *J. Exp. Med.*, 1924, xl, 133.

land 57¾, Italy 10½, Russia 4⅓, Sweden 46⅓, Switzerland 82½, the United States 11½. In this list Switzerland is highest, with 82½ scientists per million of population. Holland is second; Germany third; the United States is eighth, with only two of the ten countries below her. In proportion to the population, Switzerland had over seven times more scientists than the United States, Holland had five times more, Germany over four times more, and Sweden four times more. This statistical study gives forceful answer to the question regarding the need of organizations like the Sigma Xi, 38 years ago, in the United States.

FLORIAN CAJORI

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ENLARGED PARATHYROIDS IN RACHITIC CHICKENS

IN truly rachitic chickens, enlargement of the parathyroid glands occurs with remarkable constancy. Similar enlargement of the parathyroids of rachitic mammals—particularly rats and the human—has been reported by several investigators, such as Erdheim, Ritter and Pappenheimer and Minor.

This enlargement of the parathyroids in rachitic chickens is a very useful means for differentiating between rickets and various other morbid conditions that occur in birds used in nutrition investigations. For instance, in the pathologic condition commonly known as "legweakness," it frequently becomes necessary to differentiate between rickets and some other condition that may give rise to leg symptoms in chickens.

The ease with which the chickens' parathyroids may be found and their remarkable responsiveness to the rachitic process make them a valuable criterion for judging the presence or absence of rickets.

L. P. DOYLE

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FALL OF A METEORITE IN BRITISH COLUMBIA

A METEORITE was heard and seen to fall, and the incandescent pieces were seen to splash from the top of the mountain on the north side of the water supply creek of Manitou cannery, on the west side of Dean channel, British Columbia, between nine and eleven o'clock in the evening of August 3. This place is about opposite the mouth of Dean River. It was both heard and seen by Mrs. Harlan I. Smith, of Ottawa, Ontario, Mr. Milo Fougner, of Bella Coola, B. C., Mr. Andrew Widsten, Dominion Fishery Patrol officer, of Bella Coola, B. C., and Mrs. Humphrey, wife of the cannery caretaker. Mr. Smith and Mr. Humphrey heard but did not see it. Some passengers on the steamship *Camosun,* of the Union Steamship Line of Vancouver, then at the cannery wharf, also possibly saw or heard this meteorite. The sound was heard almost simultaneously with the sight.

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SPECIAL ARTICLES

ON THE UPPER CRITICAL CONCENTRATION OF OXYGEN IN ROOT GROWTH

THE writer has shown that in event of a deficiency of oxygen in the atmosphere of the soil the rate of root growth varies inversely with change of temperature[1] and that the "minimum" oxygen supply is not a fixed supply but that it also varies, but directly, with temperature change.[2] Such concentration has been termed the lower critical concentration.[3] The lower critical concentration of oxygen is thus the least concentration at which growth will take place at any temperature.

In considering the relation of root growth to available oxygen it will be apparent that there are four cardinal concentrations. Of these, one, the lower critical, has already been defined. Another concentration is that at which growth is "normal." This is termed the upper critical concentration. Between the lower and the upper critical concentration exists an oxygen deficiency, as will be seen. But above the upper critical concentration an increase in the amount of oxygen does not apparently induce change in the growth rate until a certain and possibly high concentration is reached, when the rate may fall. And, finally, the concentration may apparently be so great as to bring about entire cessation of growth. Such would be the maximum concentration. Of the upper optimal concentration, the range of the optimal or of the maximal concentration or the range of the supraoptimal, this note has nothing to do. Attention, however, should be called to certain apparent characteristics of the upper critical concentration of oxygen in root growth.

The upper critical concentration of oxygen, as above defined, is such partial pressure as will just permit a "normal" rate of root growth at any given temperature. For the reason that the oxygen requirement of roots varies with temperature changes, the actual concentration for the upper critical is greatest at the highest temperatures and least at the lowest temperatures. A test of what the upper critical con-

[1] "The influence of the temperature of the soil on the relation of roots to oxygen," W. A. Cannon, SCIENCE, n.s., 58: 331, 1923.

[2] "A note on the relation of root growth in the soil to the oxygen supply: The growth ratio," W. A. Cannon, *Ecology,* 5: 319, 1924.

[3] In a study on roots and aeration, unpublished.

centration may be is had by maintaining the temperature and other environmental conditions as constant as possible, while at the same time the amount of oxygen is varied. If, upon increasing the concentration, the rate of growth is increased, the partial pressure tested was less than the upper critical; but, on the other hand, if the rate remains unaffected, the concentration either is that of the upper critical or above. By varying the oxygen partial pressure in such fashion a point will at length be found at which a decrease in the oxygen supply will decrease the rate, but an increase will not accelerate growth. Such concentration will be the upper critical. Whether, in practice, the actual upper critical can be closely determined, can, perhaps, be questioned. However, this is not especially important; one or two per cent. either way, in face of so great partial pressure, does not affect the matter greatly. The point to be made is that the upper critical concentration is a cardinal concentration of oxygen for growth of the root and is related to the temperature. Like the lower critical, the partial pressure of oxygen necessary to effect a certain rate of root growth, other factors being constant and equal, varies, as suggested, with the temperature.

Little is now known relative to the range of the upper critical concentration of oxygen for root growth, either as to its possible range with temperature changes, or as regards different species. Work touching the general subject is now in progress. Enough has been done, however, to give an idea of both of these features for two or three species. And some of these results can be mentioned in the present note.

It has been found that in such species as Pisum and Zea, under "normal" conditions of soil aeration, an added amount of oxygen, such as would be had by passing atmospheric air through the soil, may increase the rate of growth. This, however, apparently occurs only at high temperatures of the soil. Be this as it may, it has been determined experimentally, in a tentative way, that under the conditions of the experiment, and with relatively low air temperatures, a soil atmosphere containing 10 per cent. oxygen induces about normal growth of the root at a soil temperature of 30° C. At soil temperatures 10 degrees, or so, below, however, a rate normal for the temperature will go on in about 4 per cent. oxygen, the air temperature remaining about as before. The range of the upper critical concentration of oxygen in root growth is therefore approximately 6 per cent. in Zea. Apparently about the same range of the upper critical concentration is to be had in the cotton, which also requires a good oxygen supply for root growth.

The upper critical concentration in such species as are relatively tolerant to oxygen deprivation, however, such as the orange and willow, is apparently of another order than that for Zea. Although the matter has not been sufficiently investigated so as to speak with surety, it appears possible that normal growth of the root will take place in the orange at 27° C. soil temperature when about 1.2 per cent. oxygen is present in the atmosphere of the soil, but apparently more than this amount is required in the willow to bring about a normal growth rate of the root at 30° C. In both species relatively active growth at low temperature of the soil will take place in about .5 per cent. oxygen. In such species, therefore, the range of the upper critical concentration as associated with temperature change, is relatively small. And as the upper critical concentration is not large and the lower critical concentration is small the range of oxygen deficiency in such species as orange and willow is likewise small. In either it may not exceed 1.5 per cent. Very possibly the lower critical concentration for the high temperatures, in such species, is about the same as the upper critical concentration for low temperatures. This will be seen to be very different from the condition which obtains in Zea and Pisum, in which the difference is relatively great, as indicated above.

It has been known for some time that different species may have unlike relations to oxygen, but such possible differences have been based on observations of the least amount of oxygen consistent with root growth. Temperature has not been taken into account until recently. When comparisons have been made to the known oxygen content of the soil it has been difficult to associate such findings with those from the experiments for the reason that the soil usually contains more oxygen than would be called for in the lower critical concentration. Hence an ecological application has not been clear. However, there is now known to be a relation between the amount of oxygen held in solution and the partial pressure required for the lower critical, in all species, and for the upper critical concentration in such as occur in substrata which are saturated with water. From what has been said above relative to normal rate of root growth and the oxygen supply, it appears possible that the ecological application must be sought rather in the oxygen requirement of the root for a normal rate of growth for any temperature. But in referring to the temperature as a limiting factor it is also recognized that other factors, especially those associated with the shoot, may also be associated factors, possibly of as great importance as temperature, but not likely. However, nothing is known as to this, and the striking relation remains between

the supposed oxygen content of most soils and the known oxygen content necessary to produce normal growth at any temperature in a few species. There remains one difficulty, however, which should be bridged. No direct work correlating the results of field studies on oxygen content and those in the laboratory on oxygen requirement have been carried out, although it will have been seen from what has been suggested above that such would be required before the ecological application of physiological findings is possible. In other words, we are now beginning to learn that plants require different and determinable amounts of oxygen for root growth, but we are as far as ever from making use of this knowledge either in the field or in cultural practices.

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THE SEED-CORN MAGGOT AND POTATO BLACKLEG[1]

ON account of the lack of evidence to the contrary plant pathologists in general have assumed that "infected seed tubers are the sole source of infection and distribution" of potato blackleg.[2] Since all experiments have indicated that the pathogene does not hibernate in the soil,[3] it has been assumed also that the pathogene hibernates only in partly decayed tubers. The writer has obtained evidence recently which shows that the seed-corn maggot, *Phorbia fusciceps* Zett., is a common agent of dissemination as well as inoculation of potato blackleg in Minnesota. Preliminary experiments indicate also that the pathogene may be biologically transmitted by the insect, thus providing another important means of hibernation.

Eggs of the insect are deposited on the seed pieces before planting. It has been demonstrated that the eggs may be contaminated with pathogenic bacteria when deposited. The larvae have been found in a very large percentage of seed pieces under diseased plants and have never been observed in the seed pieces of plants not affected with blackleg. The larvae leave the decayed seed pieces and enter the soil to pupate before or shortly after the symptoms of the disease first appear on the shoots. This probably explains why they have not been observed more frequently.

The larvae of the insect act as agents of inoculation by burrowing into the seed piece, introducing the bacteria and at the same time aiding the development of the disease by inhibiting the normal tendency of the seed piece to cork off the decay. In experiments extending over three years, more than five hundred seed pieces, partly decayed by *Bacillus phytophthorus* Appel, have been planted in both wet and dry soils. Every seed piece, with the exception of a few that decayed completely before sprouts could develop, successfully warded off the decay and produced a healthy plant. The seed tubers were handled so that no flies could have gained access before planting and no larvae were found in the seed pieces. On the other hand, when nine sound seed pieces, each bearing one or more eggs, were planted, two cases of blackleg developed. Larvae were found in the seed pieces of these two plants but not in the remaining seven. Most of the eggs used were of unknown age and therefore of doubtful viability. If all the eggs had been freshly deposited, in all probability a larger number of diseased plants would have been obtained.

Phorbia fusciceps is known by entomologists to be parasitic on a large number of crop plants. It has been reported as attacking beans, corn, peas, turnips, cabbage, radish, onion, beets, tomatoes and "seed potatoes." It is widely distributed throughout the United States. In descriptions of the injury done by the insect, invariably mention is made of the decay which follows it. Its life history and means of hibernation are imperfectly known.[4]

These discoveries have a very important bearing on the application of control measures for potato blackleg. In numerous cases investigated by the writer in which high percentages of blackleg had developed in spite of seed disinfection, almost invariably the tubers had been disinfected several days before planting and had been left exposed. The usual seed treatment methods would kill any eggs on the tubers at the time, and as larvae were found in the seed pieces of diseased plants, eggs must have been deposited after treatment and without doubt were the source of infection. Where seed tubers have been disinfected and planted *immediately*, very little blackleg has been observed. If seed disinfection is to control blackleg, it appears that the treated tubers must be planted immediately after treatment or else stored in a place inaccessible to flies.

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[1] Published with the approval of the director as Paper No. 495 of the Journal Series of the Minnesota Agricultural Experiment Station.

[2] Morse, W. J., "Studies upon the blackleg disease of the potato, with special reference to the relationship of the causal organisms," *Jour. Agr. Res. 8*: 79–126. 1917.

[3] Rosenbaum, J., and Ramsey, G. B., "Influence of temperature and precipitation on the blackleg of potato," *Jour. Agr. Res. 13*: 507–513. 1918.

[4] Gibson, Arthur, and Treherne, R. C., "The cabbage-root maggot and its control in Canada with notes on the imported onion maggot and the seed-corn maggot." *Dept. Agr. Canada Ent. Bul.*, 12. 1916.